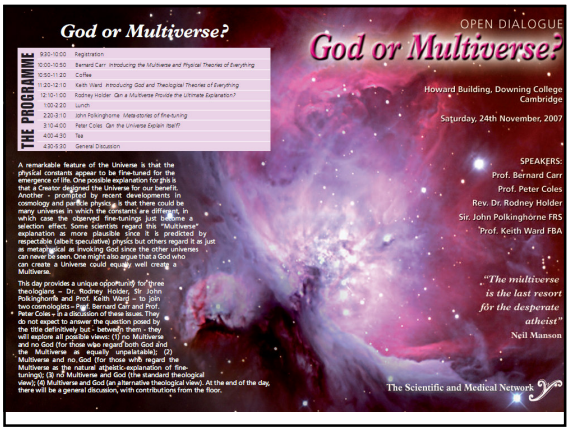
Wednesday, December 5, 2007

Vilenkin Part IV

Agenda

- Announce:
  - Finish your projects!
  - Last "real" lecture!
- Part IV



Ch. 16—Did The Universe have a beginning?

- Has it existed forever or did it start at some time?

An Oscillating Universe

- Expand
- Contract
- Big Crunch
- Big Bang
- Repeat!

But the entropy must get reset to a low value!

Steinhardt & Turok Fix it

- Expanding fireball
- Vacuum energy dominates
- Slow inflation for a long time
- Eventual collapse (minimal collapse)
- Big Bang & repeat

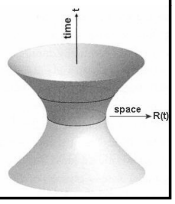
Volume keeps increasing, so entropy can as well! But…entropy in our observable universe can be made small by collapse

So, does it have a beginning?

- W/ eternal inflation or cyclic Universe, might think Universe could have existed forever (no beginning)
- Still need to keep thinking

De Sitter Space

- Inflation described by De Sitter space (in simplified version…homogenous)
- If we look to late times, no problem…keeps inflating
- If we look backwards, we find island universes must have begu in a Big Bang



Generalize…

- Choose some people/observers in the universe predicted by eternal inflation
- If the universe had *no* beginning…
- Then observers' paths should extend infinitely into the past
- But they don't…so there's a contradiction
- Universe had a beginning
- Also applies to cyclic universe since it too involves continued, average expansion

Ch. 17—How did things begin then?

- Classically, at the beginning, if the Universe was
  - **Small**…not much vacuum energy, regular energy/mass dominates and Universe **collapses**
  - **Large**…vacuum energy dominates, and Universe **expands**
- But, quantum mechanically, small Universe can tunnel to larger one and inflate

Nucleation From Nothing

- Nothing existed
- Quantum fluctuations occur randomly
- At many of these, Universe is born, recollapses and is gone
- At one (more?), small Universe is born, tunnels to bigger one, inflates, and here we are!

Similar to existing idea

- Quantum fluctuations would eventually produce patch of inflating region
- Region expands and pinches off into its own Universe
- Energy still conserved: negative gravitational potential energy balances positive energy
- Problems:
  - Small probability
  - Assumes existence of "mother" universe…doesn't answer question of origin

Ch. 18—How will it end?

- W/ no cosmological constant:
  - Closed (overdense)—fireball as universe collapses
  - Critical—expansion continues to stop
  - Open (underdense)—heat death, everything expands away
- Like launching a space craft…throw very fast, too slow, or just right

How will it end?

- w/ Infation
  - Driven to critical density
  - Greater Universe continues—inflation is eternal
- w/ Cosmological Constant
  - Local group continues to exist (galaxies within merge)
  - All else disappears from view
- Cosmological "Constant" might decrease…when it goes negative, Big Crunch
- String-motivated ideas propose creation of bubbles of negative cosmological constant which, if they bump into us, would annihilate us

Does Inflation work?

- Does it explain things?
- Does it do so better:
  - More elegantly
  - Fewer assumptions
  - Fewer ad hoc arguments
  - More naturally

What's the difference between an O-region and another (island) Universe?

A. No difference
B. Things in our O-region can affect things in another, but not so for Universes
C. Things in our Universe can affect things in another, but not so for O-regions

What's the density of the Universe?

A. Underdense
B. Critical
C. Overdense

What is not a difference between inflation and a cosmological constant?

A. Inflaton evolves in time
B. Inflaton has negative pressure, but constant does not
C. Inflaton implies exponential expansion but constant may just produce "mild" expansion

What does it mean to say that the vacuum energy comes to "dominate"?

A. When there's not much space, then vacuum energy is more important than regular matter
B. When there's lots of space, there's lots of vacuum energy which becomes more important than regular matter

Why does vacuum energy mess up easy picture of closed/critical/open?

How does the scalar field get to the top of the hill?